# MACHINE TOOL DEVELOPMENT WITH SPECIAL REFERENCE TO THE USE OF CARBIDE TOOLS AND HYDRAULIC MECHANISMS.

*Paper presented to the Institution, Luton and Coventry Sections, by J. D. Scaife, M.I.P.E., Past President.*

TO deal in an adequate manner with the two headings as stipulated in the title would mean leaving out anything in the nature of a general review of machine tool design. In fact, to deal with the second part in a suitable fashion for this Institution would require all the time at my disposal. It was also necessary to change the title to suit the development of other metallic carbides, for as you know there are carbides of other metals available now, which, whilst exhibiting all the advantages of carbide of tungsten, do not have the same tendency to adhere to steel, and consequently have a better finish obtainable.

My remarks therefore, with reference to the use of carbide tools will be confined more or less strictly to the influence which the new cutting materials are having on machine design rather than any attempt at complete descriptions of any machine which may be referred to. It would appear to the author that the main points of design which have required to receive special consideration are :—

(1) Speed (range and variability).
(2) Rigidity.
(3) Balance of high speed shafts.
(4) Main spindle bearings.
(5) Swarf handlings or controlling.
(6) Slide coverings.
(7) General utility—reduction of cost, handling, time, etc.

Probably the biggest step of recent years in the march of progress in the machine shop is the development of carbide tools. This class of materials which is made up of minute grains of the carbides of tungsten, molybdenum, and titanium, etc., and bonded by a special process, possesses a high degree of hardness and resistance to abrasion, but at the same time is very brittle.

Its efficiency as a cutting medium is seriously affected by a lack of rigidity either in its own support or of the work. Consequently a

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wide field of research has been opened to the machine tool designer to provide equipment capable of using the new material at something approaching its full capacity.

It must not be understood that new machinery is absolutely necessary to make the use of carbide tools worth while, as a wide variety of materials of hitherto difficult machining properties can, by its use, be conveniently dealt with on machines not specially designed for high speed. For instance, high tensile steels of a hardness hitherto incapable of cutting can now be handled in a heat treated condition throughout, and heat treating distortions avoided. Also for tools which are required to retain size over a long period to avoid expensive tool setting, carbide tools are an undoubted boon. One firm in America is actually cutting hardened steel screw gauges from the solid by means of carbide tools, although grinding will undoubtedly be the method of the future for this particular class of work.

However, even having regard to the numerous advantages which carbide tools can provide using machines not built for carbide tools, the bulk of machine operations are carried out on materials which are readily machined by any kind of tool steel, and it is therefore that class of material which offers the greatest opportunities for improvement of machine tool design.

## Speed.

Obviously, the first requirement is higher speeds. From recent experience it is now necessary to provide for a cutting speed of 1,000 feet per minute or more on cast iron and steel, and at least 2,500 feet per minute on non-ferrous material. Several English makers are now providing for speeds as high as these. They do not, however, provide what is most necessary to efficient cutting, that is, a sufficient range of speeds in the higher regions. To examine the speed ranges of practically all lathe makers' product will show wide gaps at the higher speeds. This has been found to be a distinct drawback to the efficient utilisation of carbide tools as the effective cutting speed might well be above the next lower speed. I forecast that a variable speed motor in conjunction with existing gear changes will be the feature of new lathe design, on the lines of the new heavy duty lathes of Messrs. Holroyds', etc., mentioned later, and the Noble & Lund lathe (Fig. 3), which is fitted with a B.T.H. Variable Speed A.C. motor.

## Rigidity.

With the increase in speed, follows the need for greater rigidity, but as this is a matter which can only be considered in the light of each case on its merits, it is difficult to lay down any hard and fast lines. The only direct suggestion one can offer is the use of box beds resting entirely on the floor, in preference to shallow beds resting on

legs, but by whatever means the result is achieved machines must be rigid in operation.

## Balance.

The brittle nature of carbide tools makes it essential to have all high speed revolving shafts properly balanced. Otherwise vibration will exist and cutting efficiency considerably reduced.

High spindle speeds, plus the necessity of little or no bearing clearance, have almost forced the issue as regards plain or antifriction bearings for several reasons. One is that it is an expensive business to maintain plain bearings on metal cutting machines in a satisfactory working condition. Another is that a rigid bearing (that is, one in which no slack is present) is found most suitable for main spindles of machines using carbide tools.

There is no doubt that the clearance necessary in a plain bearing permits a slight shiver which is destructive to the fragile edge of the tool. Another reason is the great increase of power consumed in a close fitting plain bearing.

## Main Spindle Bearings.

Three general schemes are available, all of which find favour amongst machine tool builders.

One is the scheme (Fig. 1), developed about the time carbide tools

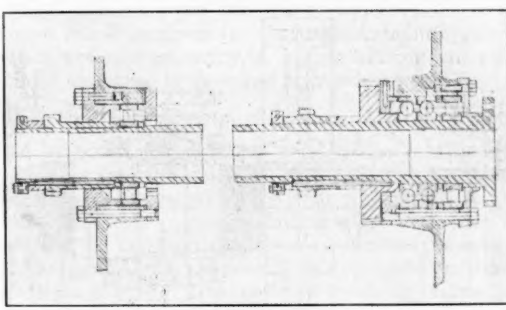

Fig. 1.

were first introduced by Messrs. Ransome & Marles, Ltd. In this arrangement which is adopted by Messrs. Alfred Herbert, Ltd., in their new machines, special close fitting roller bearings take the journal load whilst pre-loaded double purpose bearings take the thrust in either direction. These latter bearings, whilst not taking any perceptible journal load, are so arranged that they fit the shaft and the bore of the housing and thus have the affect of preventing

any tendency to whip. This arrangement, I may say, would not be satisfactory with standard bearings on account of the excessive eccentricity. These super accurate bearings have less than .0001-in. eccentricity in the raceways, and the balls and rollers themselves are selected to a much smaller variation than for standard bearings. The design of the double purpose bearing lends itself particularly to high speed work much more than the regular type of flat thrust bearing which is more unreliable as the speed increases.

For speeds up to, say, 1,000 r.p.m. the roller bearings are cageless, but for over that speed, bronze, bakelite or duralum cages are fitted. Messrs. Wards are using a roller bearing arrangement, but I understand a decision regarding a standard design has not yet been reached.

The second arrangement is that of Messrs. Timken, Ltd., which has found favour amongst many machine tool makers. Given the same degree of accuracy both arrangements are satisfactory. As the latter, however, require to be adjusted during assembly the efficient running of the spindle depends entirely on the judgment of the machine erector, whereas in the former arrangement the nature of the loading is pre-determined by the bearing manufacturers.

For heavily loaded spindles taper roller bearings should be used in pairs to prevent the tendency to endwise movement when heavy journal loading is applied. There is a further arrangement (Fig. 2)

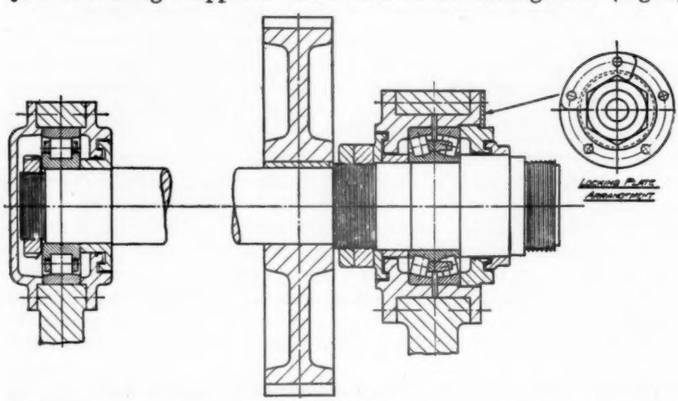


Fig. 2.

used by John Lang, using a double spherical roller bearing. Extremely successful results are justifiably claimed for this arrangement which does not require the same accuracy of the alignment of the bearing housings. At the same time it must be agreed that the

resistance of the spindle to spring under the cut or to whip at high speeds is dependant entirely on the stiffness of the spindle as there is no support from the bearings.

For centre lathe work this point is not of importance, but for turret lathe and milling machine spindles some additional support to resist spring and whip is desirable. The introduction of a third bearing, however, necessitates accurate alignment and the self-aligning feature of the front bearing ceases to be an advantage. A further point of comparison is the reduced area of contact in the latter arrangement.

The barrel roller being a compromise between a taper roller and a ball, the area of contact of the rollers on the raceways whilst being considerably larger than that of a comparative ball is still much less than that of a parallel roller, and the life of the latter must be correspondingly longer if (a very important " if ") the accuracy of the component parts of the bearings and their housings is of the necessary high order. Standard limits adopted by ball bearing manufacturers are not nearly close enough for this purpose and if super quality bearings are not available, the spherical type bearing arrangement is undoubtedly superior.

## Turret Roller Bearing.

An important detail but representative of the thoroughness which Messrs. Alfred Herbert's put into their constructions is the roller bearing turret which preserves the alignment indefinitely and without the clearance which is necessary in a plain bearing, the roller being made without clearance is therefore tight when fitted.

## Swarf Handling.

The rate by which metal can be removed on a lathe by carbide tools provides a real difficulty in regard to the accumulation of swarf. Steel especially can be removed at such a rate that unless an efficient chip breaker is used the limiting speed is reached far below the capacity of the machine or the tool, otherwise the operator is in danger of having his head sawn off if he approaches within an arms length of the machine. This point is receiving attention by all prominent lathe makers and chip breakers are being applied. Suitable swarf trays of large capacity, which can be removed or emptied from the back of the machine are necessary. Serious attention is being given to the design of machine beds to reduce the obstruction to the free passage of chips from the tool, and machine tool makers are making this a prominent sales feature. A recently designed machine of Messrs. Holroyds, which I have previously mentioned, shoots the chips clean off the bed. Messrs. Ward, Haggas & Smith also arrange their lathe beds to avoid the lodging of chips, and all leading lathe makers are giving attention to this matter. The

large amount of material removed has emphasised the necessity which has always existed for providing efficient slide coverings for even in the past this point has been badly neglected.

## Slide Covers.

The arrangement adopted by Messrs. Alfred Herbert, Ltd., is one where the covers actually rest on the slide. The one adopted by Messrs. H. W. Ward, Ltd., is slightly removed from the slide, but is made from steel. You will know the various merits and demerits of both arrangements if you have been in the market for combination turret lathes, and interviewed the respective salesmen.

## General Utility.

The extraordinary reduction in actual machining times has increased the necessity for the adoption of quick acting fixtures, either air or hydraulically operated. The majority of machine tool makers are now giving serious attention to such features. Sunstrand auto indexing features are a case in point. Reference is also made to the increased use of air chucks on lathes, etc., which for repetition work are a good investment.

Having briefly outlined the general principles by which he tdesign of machine tools has been affected by the introduction of new cutting mediums, I have selected a few examples in which attention has been given to those principles. It would require more time than I have at

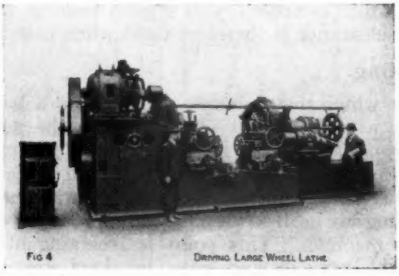


Fig. 3.

my disposal, to refer to more than a few, and it must not be assumed that those to which reference is made have superior merits to those not mentioned. They are used by way of example only.

The Herbert No. 10 and Ward No. 10, measured by the highest standard of metal removing ability together with close adherence to size and convenience of handling, leave little to be desired. They are both fitted with antifriction bearings of proved durability. In

the former case the main spindle arrangement is the standard recommended by Messrs. Ransome & Marles, Ltd., whilst in the latter case I believe Messrs. Hoffman's arrangement is employed. Both machines are rigidly built and provide a good selection of speeds and feeds. Slide covers are fitted in both cases as previously mentioned. I should say that each machine is capable of absorbing 100 h.p. if required. In the former case the slides are ground by

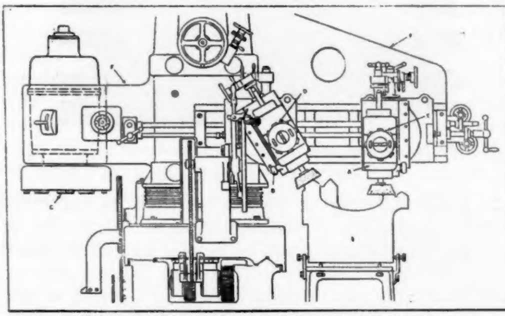

Fig. 2. End View of Way Grinder of Traversing Head Type, Showing Application to Lathe Bed

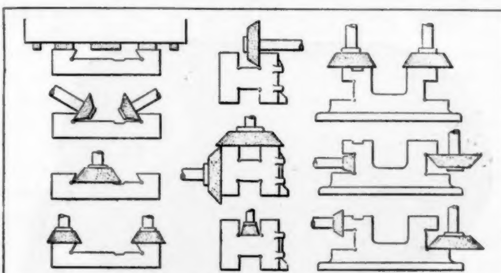

Fig. 3. Typical Examples of Work Done on Way and Slide Grinder

**Fig. 3a.**

means of the flat formed wheel. Herbert No. 8 and Ward No. 7 are similar machines but somewhat smaller, and the same remarks as for the two machines previously shown, apply to these.

Special mention might be made of the fact that both these machine shave their main slides ground. In the former case by means of a straight formed wheel, and in the latter case by means of a cup wheel (Fig. 3a). The latter method is, in my opinion, far superior to the former for several reasons. One is that the cup wheel principle generates a truly flat surface. Another is the better reten-

tion of the lubrication on the slide under pressure. Then again practically all sliding surfaces on any slideway can be ground at the one setting. A further reason is that the effect of vibration, if any, being parallel with the ground surface of the grinding spindle is not visible on the work with cup wheel grinding as it is with the flat formed wheel. If properly performed, either method, however, is

Fig. 4.

superior to hand scraping in respect to their better resistance to breaking down under heavy sliding pressure. In course of time, I have no doubt, hand scraping will be as obsolete as the hand lathe is to-day. The German machine referred to is well and accurately made, but it should be more rigidly built, and the lack of wheel speed range is a serious disadvantage. Messrs. Archdale and Messrs. Ward, and Messrs. Parkinson are using the cup wheel method.

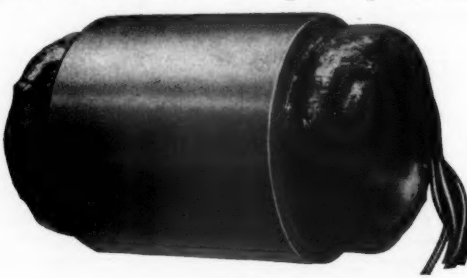

Fig. 5.

The Herbert No. 5E is a fine example, of which we have had so many recently, of the co-operation of the electrical engineer with the machine toolmaker. The main spindle is itself a motor with a four speed switch. Fitted with an air chuck and well thought work changing equipment, it is what the Americans call a fast worker. I have no doubt that the next step will be to cut out the steps in the speed range.

The rotor and stator unit (Figs. 4 and 5) embodied in the last machine is made by the B.T.H. Co., and there is no doubt in my

mind that the future will show considerable development of the use of built in motors. The advantages are enormous. Reduction of cost and weight are important considerations and with such constructions, the motors can be tucked away out of sight and out of danger. In a recent Craven lathe the usual traverse and feed shafts are conspicuous by their absence and the motors themselves are not obvious.

The Magdeburg lathe is an example of a lathe embodying the ideal arrangement of offering a stepless variation of spindle speeds between the top and bottom speeds. The speed range being obtained by means of a Lauf Thoma system of pump and motor, which is supplemented by gearing. The hydraulic system will be referred to later. In practice the chief objection is the loss of power due to the low efficiency of all oil pressure systems, viz., from about 70 per cent. to 80 per cent. under the best conditions as against say 95 per cent. to 97 per cent. of a well made geared headstock. In a lathe using say 50 h.p. the direct loss of 10 h.p. would be no small item in the cost of running the machine although the advantage of more closely approaching the best cutting speeds of carbide tools is not inconsiderable. The method employed by Messrs. Noble & Lund and Messrs. Holroyds of using gearing together with a variable speed motor is to my mind a better and more satisfactory system.

The Lang $8\frac{1}{2}$-in. engine lathe. This machine is a good example of heavy duty lathe and will handle carbide tools to their limit of cutting capacity. The bed and slides are covered. The Holroyd heavy duty engine lathe is really well worthy of its description. As it has previously been mentioned in a paper to this Institution I need not go into too much detail. However, I cannot pass without mentioning some of the very excellent features: (1) Any desired cutting speed within the highest and lowest can be obtained: (2) Loose headstock spindle revolves with the work. Centres whether live or dead are a continual source of trouble under heavy duty conditions, and the arrangement adopted appears to be a distinct step forward. The loose headstock spindle can be revolved for drilling and boring short holes in the ends of shafts which are also slowly revolved to maintain axial truth of the hole. It is obvious that this machine has been designed and built for the heaviest duty.

The Drummond No. 0 manufacturing lathe will be known to most of you. The slides are operated by means of a hydraulic low pressure system.

The Archdale plain knee type machine is a good example of its type as also is the Herbert No. 33 plain machine. The main spindles running in Timken roller bearings in the first case, and Ransome & Marles parallel roller bearings in the second case.

The Cincinnati heavy duty milling machine is in the front rank of heavy duty machines. Being built on the unit principle the design

is more readily adaptable to varying requirements than is usually the case with machine tool designs. All machines turned out by this firm are elaborately jigged and a high standard of interchangability is aimed at. Main spindles run on taper roller bearings and all revolving shafts run in either ball or roller bearings. The table is moved hydraulically and whilst the arrangement has some special claim to merit, I do not think the principle will ever be in general use. Even in this machine I am confident that a screw operated by some variable speed mechanism would be superior. The hydraulic mechanism will be referred to in the next part of this paper. A large Schoenherr slideways grinder was recently installed in these works, so evidently the Cincinnati people favour the cup wheel machine.

## HYDRAULIC MECHANISMS.

The history of the application of hydraulic mechanisms to machine tools, except for a few isolated instances, goes back only some fifteen or twenty years. The first machine of international repute fitted with hydraulic table traverse and with which the writer had intimate contact, was the heald internal grinder, although by that time the idea of moving the table slide of a grinding machine by means of oil pressure was some years old. Since then makers of other machines have followed suit, until now quite a fashion has set in for hydraulic mechanisms, and only experience will decide in what instances the use of hydraulic pressure is superior to mechanical means in the functioning of machine tools.

### Movement of Slides by Hydraulic Pressure.

The development has so far progressed, however, that it can be stated I think without any doubt that the rapid movement and reversal of slides against a comparative small resistance and where a definite relationship does not exist between the rate of movement of the slide and some other moving part of the mechanism, can be performed much more satisfactorily by hydraulic means than by any mechanical method known.

In the case, say, of a plain centre grinding machine, the advantage is so marked that one is almost entitled to class a mechanical drive machine as obsolete. From that case, however, to the actuation of a tool, milling cutter or broach where the resistance is comparatively high and varying in intensity by a hydraulic system employing the direct application of a piston, there are grounds for much controversy. Certainly there does not appear to be sufficient grounds for substituting hydraulic means for mechanical means for moving the tool slide on a lathe or a planing machine table. In spite of metering system or any other form of control, it is inconceivable that the elasticity which is such a desirable feature of hydraulic mechanisms in some applications will permit of the necessary accuracy of feed

control in the case of the lathe, or of the steadiness of movement of the planer.

It must be understood in the foregoing remarks that it is the *direct* application of oil pressure which is referred to. That is where the actual movement of the tool is governed by the quantity of oil let into or withdrawn from a cylinder by either a low or high pressure system. One cannot overlook the advantages of flexibility of rates of traverse in the approach and return of tool slides, but this flexibility of control should be applied *indirectly* and not directly through a piston.

Generally speaking direct hydraulic pressure mechanisms have only demonstrated their superiority over mechanical motions in cases where the speed is high and the resistance comparatively steady, and in those cases, such as the operation of grinding machine table slides the advantages of speed, ease of speed control and smoothness of reversal are altogether in favour of hydraulic systems.

The hydraulic rotation of main spindles has not yet been developed to any marked extent. The Magdeburg lathe, the Fortuna Werke grinder,and the Lund cylindrical grinder being three examples of this practice. Apart from any technical considerations the cost of a hydraulic system powerful enough to drive a modern turret lathe would be entirely out of proportion to any possible saving which its adoption could achieve. From a technical point of view there is nothing to be said against such applications, in fact there would be some advantage in the compactness of design but an electric motor with a speed variation sufficient to cover the gaps in the gear speed range meets all requirements at much less cost. In the case of the work head drive of a cylindrical or internal grinding machine a different set of conditions are met with. In the first place a gear box is out of question on account of the risk of chatter and therefore some form of variable speed drive with a speed variation of say, 15 to 20 to one is desirable. It will be evident from this that as the power of an electric motor drops considerably with the drop in speed the frame size of the motor is based on the power at the lowest speed and a somewhat bulky construction is the result, that is, of course, if adequate power is provided to grind at a rate which is in keeping with modern grinding requirements. After careful study of the matter the author is of opinion that the application of a variable speed hydraulic motor to the work head of a cylindrical or internal grinding machine is ideal and justifies the extra cost.

One of the earliest of its type, and still one of the best is the *variable speed gear* (*piston type*) (Fig. 6), made by Messrs. Vickers; the view shows the pump unit. The central shaft rotates with the cylinder block and the inclined thrust plate. Smaller inclination on the swash plate reduces the delivery of oil and increases the pressure. The motor unit is similarly constructed except that the swash plate

has a fixed inclination. The motor speed varies with the amount of oil received. The torque increasing as the oil delivery is reduced.

*The " Enor " system (vane type).* The illustration (Fig. 7) shows a pump and motor unit combined. The pump consists of a rotor movable eccentrically in relation to the cylinder. The rotor carries vanes which slide in the rotor radially, and rollers on the end of the

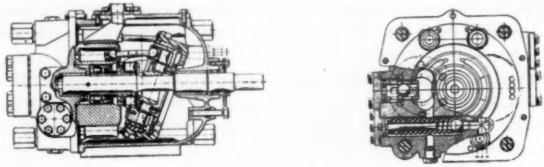

Fig. 6.

vanes run in races on the side of the cylinders which keep the vanes just clear of the cylinder walls. Rotation of the rotor therefore will give a varying delivery according to the position of the rotor in relation to the cylinder and with a constant power input the pressure increases as the delivery is reduced. The motor is constructed to allow the rotor to be moved eccentrically to give a greater speed range than can be obtained with a fixed rotor.

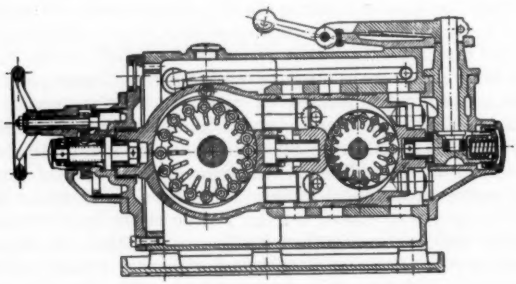

Fig. 7.

*Oil gear system (piston type).* The outer shell rotates on a fixed centre whilst the cylinder block rotates with it but on a centre movable eccentrically with the outer shell. The rotations of the shell and cylinder block cause a pumping action in the cylinders and the position of the centre shaft determines the direction of oil flow in the circuit. The motor is actuated in the converse manner.

*Hele Shaw Beacham hydraulic unit* (Figs. 8 and 9). The arrange-

ment in this system is somewhat similar to the oil gear system in that the pistons are radial. In this case the cylinder block rotates concentrically with the main drive shaft. The pistons, in moving with

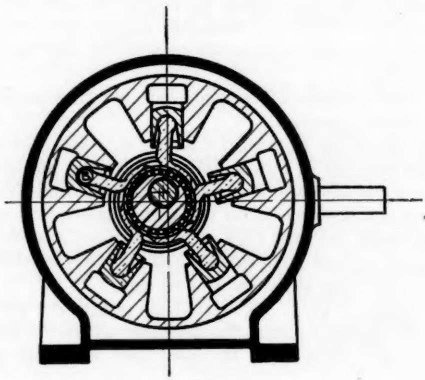

Fig. 8.

the cylinder block, are caused to make a pumping action by reason of the crank pin on which the big ends of the rods bear being

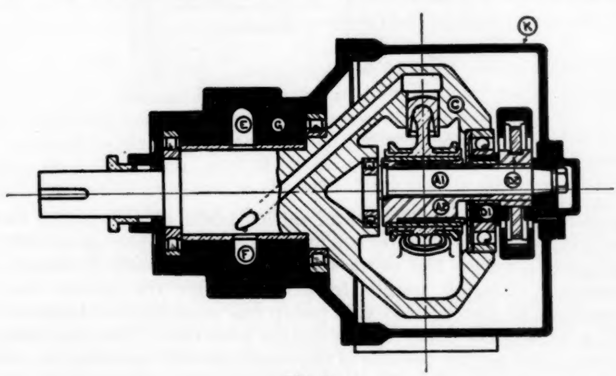

Fig. 9.

displaced eccentrically to the main shaft. The crank pin can be so displaced in relation to the main shaft that the volume and pressure in the pump can be inversely varied, but the direction of the flow can

be reversed and thus cause a reversal of direction of the motor, the torque varying inversely with the speed.

*The Lauf Thoma system* is somewhat similar to that of the oil gear and Hele Shaw in the respect that it has radial pistons. The control of the pistons in this case being by rollers running an an eccentric groove. As in the " Enor " system, the motor can be varied in speed apart from the oil received from the pump. A wider speed control is obtained thereby.

There are other designs of variable delivery pumps more or less on the lines of those described.

*Sturm and Keighley Technical College systems.*—In all the cases mentioned the amount of power delivered by the pump to the motor or cylinder is constant except for slip and frictional losses. That is, if the delivery is cut down from the pump there is a corresponding increase of pressure and for high pressure duty, and extremely slow speeds, such systems are desirable. All such systems have variable delivery and increasing pressure and torque.

" *Angular pump* " (Fig. 10).—In this pump the rotation of the shaft drives the slippers round the eccentric groove which causes the the gaps between their ends to open and close at points which

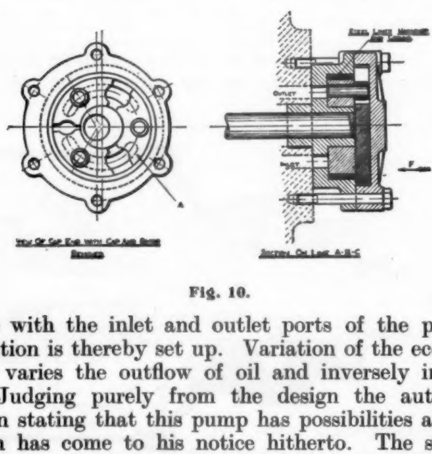

Fig. 10.

synchronise with the inlet and outlet ports of the pump and a pumping action is thereby set up. Variation of the eccentricity of the groove varies the outflow of oil and inversely increases the pressure. Judging purely from the design the author has no hesitation in stating that this pump has possibilities ahead of any other which has come to his notice hitherto. The simplicity of construction readily permits of the close accuracy necessary to obtain and maintain the high efficiency desired. Unfortunately the design will not permit of its use as a motor.

*The geared pump* is by far the nost commonly used pump for machine tool work however. In this pump both the pressure and efficiency is low compared with a piston type of pump, but for the

majority of machine tool applications it is by far the most effective when well made. In this type the amount of oil delivered is constant and that portion which is not required, is by-passed back to the tank (with consequent loss of power). This pump is not used where increased torque is required. As the power required by such pumps is generally not more than five h.p. the consequences of such losses are not economically serious.

Heating generally accompanies such drastic restriction of the flow of oil and some cooling system is advisable especially where automatic feeding is hydraulically performed.

In all types of hydraulic mechanism the finest workmanship is essential on account of the fact that the pressure depends mainly on fine clearances, the usual oil sealing arrangements not being permissible.

*Oil circuits* in principle are quite simple : their successful operation depends on proper design and construction of the various units.

*The gear pump circuit* which is the type most used, delivers a constant amount of oil. The amount required to give a desired rate of piston displacement is regulated by valve shown. The reverse valve which is usually operated both by hand and power automatically directs the oil flow into the cylinder on alternate sides. The surplus oil is by-passed back into the oil tank.

*Variable delivery pump circuit* is somewhat similar in this type of pump. The oil flow is controlled by the pump instead of being by-passed. In this case as the delivery is reduced, the pressure is increased to obtain a greater torque. The reverse valve reverses the direction of rotation of the motor or the direction of movement of a piston.

*Plunge cut circuit.*—This is an excellent example of the superiority of hydraulic systems. In this case a heavy wheel slide weighing approximately half a ton is moved quickly into grinding position by oil pressure behind the piston shown. The feed piston shown then comes into operation, and through gearing turns the feed screw inside the piston and puts on the cut. Back lash is prevented by the small piston at the back of the main piston. The rate of feed is governed by hand operated valve on pipe line into feed cylinder. An extremely high standard of accuracy is obtained by this means.

*Cincinnati hydromatic miller.*—In principle the milling slide is moved by means of a difference of oil pressure in the cylinder. The Booster pump maintains a high pressure on either side of the piston and a variable delivery pump displaces the oil from one side to the other of the piston causing the slide to move a controlled amount. A geared pump is employed to supply low pressure oil for quick movement of the slide. When not required the oil is by-passed through a valve back into the oil tank. As an example of the application of high pressure of machine tools this is probably the

most advanced, but after seeing the machine in action under extremely heavy duty, one may venture the opinion that a screw of suitable diameter fitted with some automatic arrangement for taking up back lash and driven by a variable speed motor, hydraulic or electric would be better.

And now as the patent agents put it, " Having briefly described " the construction of various types of pumps and hydraulic circuits, it may be advisable at this stage to summarise a little.

As I have previously stated, the geared pump delivers a constant amount of oil at a comparatively low pressure of up to 500 lbs. per square inch, the actual working pressure being determined by a spring-loaded by-pass valve. The oil required by the motor or cylinder to produce a desired rate of movement is controlled by some form of cut off valve, but the pressure is theoretically constant. From this it is obvious that as the by-passed oil represents loss of power the geared pump is not suitable for high pressure work in cylinders or the operation of motors where a high torque is required. On the other hand in the case of variable delivery pump, the pressure excluding internal friction and slip, is inversely variable with the oil delivered, and higher pressure and torque are possible than with geared pumps.

For the propulsion of slides of metal cutting machines the pressures are usually too high for geared pumps unless extremely large cylinders are employed, and therefore some form of variable delivery system is essential for successful operation. A most essential feature in all metal removing machines is a controlled movement of the work against the cutter, and it is this which has given most difficulty in the application of hydraulic mechanisms to machine tools.

From the pressure required to move the slide without cut to that required for maximum duty, the change represents a high proportionate increase, and whether the slide is mechanically or hydraulically operated the pressure has to be available instantly to overcome the resistance. At the same time means have to be provided to cope with a sudden removal of the resistance and still provide a controlled movement. Up to the present time a well fitting screw is the best means that has been discovered for providing this controlled movement.

Probably the best system of hydraulically controlled movement is that of the Cincinnati hydromatic milling machine which I have just described, but even in this case where the pressure is rapidly built up to suit an added resistance, the necessary pressure is not so unyieldingly applied as by a screw, and it has not yet been possible to provide the same steady rate of movement by hydraulic means as can be provided mechanically.

The successful application of hydraulic mechanism to grinding

machine slides is due solely to the fact that the maximum pressure required to move the slide under maximum duty, as compared with that required to move the unloaded slide does not vary in the same proportion, and by an adjustment of the back (or exhaust) pressure, such variations can be smoothed out.

**Valves.**

There are three types of valves in general use :—

(1) Rotary cylindrical type.
(2) Rotary face type.
(3) Piston type.

The first mentioned is preferred for the majority of applications on account of its free movement and rapid action. In common with the piston type a first class fit and lapped surfaces are necessary to ensure a minimum of leakage. The rotary face type adopted by the Heald Company on their internal grinders has the advantage of being adjustable on the valve faces, but requires rather more effort to move. It is not generally adopted by other makers of hydraulic mechanism.

**Hydraulic Mechanism applied to Machine Tools.**

In the following examples it should be understood that the selection has been made for illustration only, and not by way of any comparative merit. (*The lecturer here showed lantern slides of the machines mentioned.*)

*Magdeburg lathe.*—In this machine, as previously mentioned, the work headstock is driven by a motor through a Lauf Thoma variable speed gear giving a speed range of one to 60 in addition to gearing enclosed with the hydraulic system in the headstock. It is very unlikely that this method will be developed to any extent ; as I have said, it is more likely that a variable speed electric motor will be used to bridge the gaps between the speeds in the existing type of gearbox drive.

*Broaching machine.*—In this example the oil pressure is supplied by a Hele Shaw pump and there are now several makers of such machines hydraulically operated—principally by the oil gear system. The hydraulic system of control applied to this type of machine is wonderfully convenient in the easy selection of pulling speeds and quick return, but the elastic nature of the pull is demonstrated as each succeeding tooth of the broach enters the hole being broached. Something has been done in the design of broaches to minimise this kick, but great credit must be given to the steel makers for the development of hydraulic drives on broaching machines. I am of the opinion that this is a case where fashion has dominated design and that the same flexibility of drive, obtained either electrically or hydraulically and applied through a screw, would have developed a better machine than the new type of hydraulically controlled machines. This type of machine is operated by some such system as

the oil gear, the Vickers V.S.G. or Hele Shaw on account of the high presssure necessary, a geared pump would not be practicable in this case.

*Churchill plain grinder.*—In this example the entire hydraulic system is mounted on the moving wheel slide. A direct hydraulically driven Hele Shaw variable delivery pump is coupled to a hydraulic motor which operates through gearing and moves the slide. It is unlikely that tbis arrangement whilst being quite an excellent example of the use of hydraulic mechanism, will become established practice, as the much simpler geared pump-cylinder and piston arrangement pin forms the duty successfully and without the intervention of gearing. For long plain grinders, over 10-ft. say, the arrangement has great advantages, as pistons and cylinders become unwieldy, especially on high speed traversing. The only satisfactory alternative is the Lancashire drive as applied to high speed planers.

*Billiter and Klunz.*—This is the only example I know of a hydraulically operated planing machine. The same firm also builds Schoenherr slideways grinding machines and a machine similar to the one shown, both planes and grinds grinding machine beds. For the slide grinding operation, the ease of control of table speeds which the hydraulic system permits of a particular advantage, though I am far from optimistic regarding hydraulic drives on planing machines.

*"Lund" surface grinding machine.*—The table of the machine weighs approximately six tons and is moved at the rate of 30 feet per minute by two pistons and oil pressure furnished by a geared pump direct driven by a 15 h.p. motor.

*"Lund" cylindrical grinder* (Fig. 3).—In this case oil pressure is employed for the following functions: table movement, workhead driving, tailstock withdrawal, rapid advance and return of wheel, wheel feed (plunge cutting), wheel feed (intermittent at either or both ends of stroke), disengagement of hand table movement.

The table movement is by piston actuated by oil pressure delivered by a geared pump. The rate of traverse is controlled by hand operated valve, and surplus oil is by-passed to the tank. The workhead is driven by a hydraulic two speed vane typed motor, the oil being supplied by a variable delivery pump of similar design, a geared pump being unsuitable in this case as an increased torque is required for grinding larger diameters. The tailstock spindle is withdrawn by foot pressure on the treadle which applies oil pressure to a piston incorporated in the tailstock. Lubrication of main spindle is by oil pressure supplied by pump in main spindle casting which is arranged to carry its own oil supply. The method of hydraulically operating the rapid advance and return of the wheel head and the feeding mechanism has already been described.

*Asquith three head drilling machine* with Hele Shaw high and low press system.

A newly developed vertical spindle made by " Lund " in which the table traverse and feeding of the wheel is by oil pressure. The motor shaft is extended to enter the large diameter grinding spindle which it drives by means of splines. The various drives are by means of individual electric motors.

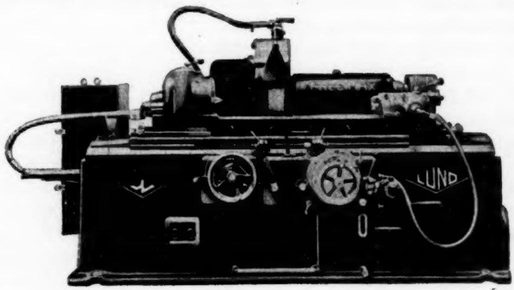


Fig. 11.

" *Lund* " *internal grinder* is a plain machine with hydraulic table traverse. An important feature is the substantial facing attachment which can be swung into position. By means of this, work can be faced in position at the same setting as for bore grinding.

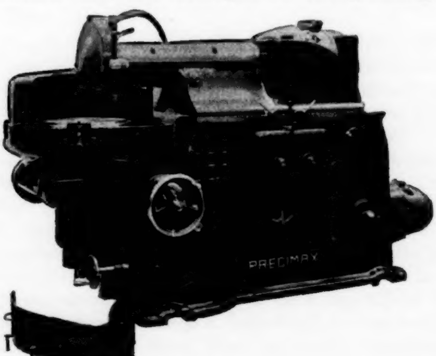


Fig. 12.

*The "Lund" ring grinder* (Fig. 3) has a number of new features, the most important being a speed variation to cover any possible requirements. The table also has a stepless speed range of five to one. Main

spindle and table spindle each have their separate lubrication systems with pressure pump for circulation of the oil through the bearings. Table traverse and feeding are by oil pressure. Push button controls are provided for all electrical gear. The speed of the wheel can be regulated to maintain the correct grinding speed down to the flanges and slight variations in the hardness of wheels can be accommodated by corresponding variation of speed.

## Discussion, Luton Section.

MR. S. CARLTON SMITH (Section President): I have pleasure in thanking Mr. Scaife for this interesting paper. I feel sure that we have all taken in a great deal of it, although it is impossible to take all of it in. There is one point which I should like cleared up. I think Mr. Scaife said that hydraulic drives were not good for the main drive of a machine. Modern developments in variable speed hydraulic motors are tending towards the provision of complete and variable hydraulic control.

MR. SCAIFE: Hydraulic mechanisms are not suitable for lathe headstock drive. For example, at the start you lose 30 per cent. in efficiency. The actual efficiency is not more than 70 per cent. and it does not improve after months of service. For operating a grinding machine slide which may absorb three or five horse-power, on the other hand, it is advantageous. Though you lose in mechanical efficiency that is not so important in that case. There is no object in being able to rapidly control the movements of your prime mover. You want to be able to change the speeds of the table. The desired object is to be able to reverse the table quickly and smoothly. You are not bound to put hydraulic mechanisms into machine heads. You do not lose efficiency with electric drives but you do with hydraulic drives.

MR. J. RONALD: I agree with Mr. Scaife's opinion that hydraulic mechanisms are not in all machine tool applications a success and certainly not a necessity. In connection with broaching, I do not consider that the hydraulic offers any advantage over existing types of machines, and the application is certainly not new. To my knowledge, a certain firm with which I was connected were pull-broaching on a machine of their own construction in 1904. Someone has mentioned that the liability of broaches to jump, was overcome in the hydraulic type of machine. My experience is that if a broach jumps when passing through a hole, it is due either to a faulty broach or a machine tool in bad condition. I cannot see how the question of the kind of power applied to pull the broach can affect the result.

MR. SCAIFE: I think there is a drawback to the adoption of the lathe headstocks of that kind, but hydraulic application to the motion of the grinding machine slide is an economical proposition in spite of mechanical efficiency losses, although not yet very successfully applied. The general application of hydraulic power is not a success. It is a success in as far as it does perform the work, but not efficiently enough. You lose 30 per cent. of your power directly in your mechanism before you start driving any part of the machine.

I do not believe in substituting hydraulic power for every other form of drive. With regard to broaching, I believe in having a thoroughly substantial screw.

MR. BAINES : May I ask if application of hydraulic mechanisms is more expensive ? One point in the favour of application of hydraulics is that it tends to lessen the fatigue of the operator. Another point is that it gives smoother work. I was surprised to hear the mention of the broach jumping. Lastly, will you give us your opinion on the application of hydraulic mechanisms in the case of plunge cut grinding ?

MR. SCAIFE : I do not wish to give the impression that I think hydraulic drives are only a " passing phase," but I feel that hydraulic systems should be developed to become more efficient. There should not be the expense in hydraulic mechanisms which there is to-day. Actually, there are less parts in a hydraulic mechanism than in an electric motor. If the cost were lower, hydraulic mechanisms would get used more freely and electric motors less. I certainly agree as to relieving fatigue. You do not have heavy levers to control. You can control tons of weight with the slightest effort. In the case of a plunge cut grinder, with a table weighing 14 cwts. and the wheel head half a ton, the amount of effort used to operate that machine is not more than eight ozs. I do not believe in hydraulic mechanism where the work resistance is high and variable. Referring to jumpiness of machine slides or tools hydraulically operated, it is not the fault of the hydraulic mechanism as such, but that it is not suitable for that particular application. Jumpiness is due to high and variable work resistance. It is difficult to so design the system that the fluid may pass smoothly through all the pipes and unions to operate as the resistance varies. The same applies to millers. In such cases, hydraulic application is only a fashion. Give me the good old screw. The case is altogether different with the table of a grinder, which moves swiftly. You have a high speed motion, perhaps of 40 feet per minute, and a relatively small resistance. You obtain the advantage of a reversal as smooth as silk, although you have a disadvantage in having to byepass an appreciable amount of horse-power.

MR. BROOMHEAD : I should like to refer to the question of broaching. Personally, I know that a number of us here to-night would like to know more about broaching—a very interesting subject. A great advantage of the hydraulically operated broaching machine is that the operator can tell by the gauge the extra pull when the broach wants grinding. On the screw controlled broaching machine, we have got nothing to tell us when it wants re-grinding. Broaching is a very important operation and costs a lot of money. To the operator it is a matter of so long as the broach goes on cutting, let it. I think that is a very serious point. Can you tell us any advantage

with regard to the life of broaches on a screw machine compared with hydraulic ?

Mr. Scaife : The question of the pressure gauge can be applied quite well if the broach is hydraulically operated. The machine must be rigid. High speeds lead us more and more to the want of heavy machines. If the screw is properly fitted there will be no jumping. I do not know of any method which automatically tells you when a broach wants grinding.

Mr. H. E. Weatherley (Member of Council) : I would like to add my appreciation to Mr. Scaife for this interesting paper. First of all I could not make out whether Mr. Scaife was in favour of hydraulics or not. I am rather surprised at Mr. Scaife's remarks questioning the value of hydraulic broaching machines. The results are so obvious to those who use them. With regard to the question of justification of their initial expense, it is relative to the amount of work you have got to do in the shop. They do the work in such a short time, that on some occasions the machine stands 80 per cent. of the time. You can even afford to let it do that. Troubles only appear in wrongly designed circuits. We do not experience any trouble. The added advantage of hydraulics is, as far as the pressure gauge is concerned, that it does definitely tell you when the broach wants re-grinding. You must not, however, in hydraulic broaching design the broach for the job, as in the old days, but you must design the broach for the machine. Design the broach for the pull, whatever it may be. You design your broach so that every tooth shall take the maximum pull of the machine. The broach makers tell you the maximum is so many pounds pressure between 1,000 to 30,000 lbs., then you know when the broach needs re-grinding. By the use of hydraulics you should get 10 re-grinds per broach and the average amount of production would be 30,000 pieces. I should like to say a few words about rotary machines. They are the " Utopia " of every hydraulic engineer. Hydraulic pumps are efficient, but we do not seem as though we shall ever get hydraulic motion as we want it. There is nothing like the Hydromatic Cincinatti machine. The makers themselves were astonished at the results. It improved production eight times, and in addition made a saving of 50 per cent. in tool costs. The figures are astonishing. Hydraulic mechanism is the best. It saves particularly on drills and any operation where tools are cutting continuously homogeneous metals. If you come across hard spots or bumps in castings, certainly the tools have a tendency to jump. But proper hydraulic equipment will take care of that. One of the greatest problems the hydraulic engineer is trying to overcome at the moment is this question of jumping or slipping.

Mr. Scaife : It would take a long time to answer Mr. Weatherley. We have tried everything we know to make hydraulic mechanism

more efficient. What we found will happen in Mr. Weatherley's case. The efficiency will fall very rapidly after a period of time. It depends on the pistons. You lose efficiency very rapidly. I should like to know the conditions on which the figures he gives are based, and the efficiency ratio under these conditions. I cannot see an efficiency of 80 per cent. in any form of hydraulic motion. To provide a variation of speed, from top to bottom you would get nothing like 80 per cent. efficiency through the range. Mr. Weatherley says 88 per cent. Even if you could reach that you could not maintain it for any length of time. You get high bearing pressure and wear. Then you cannot avoid elasticity, backlash and clatter. There is no cheap hydraulic mechanism on any job, nor on broaching machines. I much prefer the screw machine. In the ordinary machine the only thing to watch is the developing of backlash in the screw, which is the fatal part. In the machine which I described, you automatically take up any backlash.

MR. THORPE: I cannot see why in hydraulic mechanism the efficiency should fall away in a short time on account of wear in the cylinder and pistons. Pistons in hydraulic motions all work in oil. Why do we get the wonderful efficiency with motor car engines where under the best of conditions the parts have to work only partially in oil?

MR. SCAIFE: I am quite well aware of the wear that takes place in car cylinders and pistons.—(Laughter).

MR. WEATHERLEY: We have gone through our teething troubles on this question of wear. I have gone into it carefully and made records. On a hydraulic mechanism which has been working sixteen hours a day for the last five years, the wear on the piston was .0002-in.

MR. W. PUDGE (Member of Council): The same type of hydraulic unit is fitted in several makes of machines. I think its application to rapid reverse of table, also to power feed to the turret, is ideal. Another advantage of the hydraulic system is that it lends itself to remote control. The unit stands up very well to the duty, probably more so than a variable speed electric motor under the same heavy duty. On some of the large Continental milling machines the sudden shocks to the electric motor must be great, and their life probably not so long as the hydraulic unit.

MR. SCAIFE: I cannot see how you can want or get any more suitable drive for turret lathes than an electric motor of variable speed to bridge the gaps which occur between the speeds in the ordinary change-gear box. The normal application of hydraulic control is to broaching machines. I say operate broaching or milling machines by electric motor. I do not think the hydraulic motor is suitable in these cases. For tool room lathes I do not think there is any doubt that electricity is the ideal drive through a gear box. The

only other thing is a variable speed motor to bridge these speeds. The electric motor is ideal for tool room lathes. I cannot see any use for hydraulic motors on lathes.

MR. PUDGE: It is for rapid reverse and facility of control. Generally it is as good on milling machines as on grinders or broaching machines.

MR. SCAIFE: It is an unjustifiable change. The electric motor has a fly wheel action which is just sufficient to give you smoothness of cut and finely finished surfaces. Hydraulic mechanisms are admittedly easy to control from one speed to another. There are lots of other different ways of doing things, but the variable-speed electric motor for tool room lathes is ideal.

MR. LEE: The efficiency of the hydraulic motor is around 80 per cent. Therefore, 20 per cent. of your power is being continually lost. You cannot afford to have 20 per cent. lost. Generally you are going to have trouble unless you instal a cooling system for the oil. For cooling you use an electric motor. The cost of cooling has to be added to the cost of the inefficiency of the hydraulic system as compared with the mechanical system. You are paying for that all the time. My opinion is that hydraulic systems will not hold sway over mechanical systems.

MR. SCAIFE: Regarding cooling, the efficiency comes down as the oil gets hotter. The idea of cooling is to keep the viscosity the same throughout. It applies very largely to the feeding of machine tables. The feed is affected by the viscosity of the oil. Cooling is not very expensive, it is only a matter of installing a suitable cooling system. there is no doubt in my mind that the finest application of hydraulic control to machine tools is where it is used for moving a table. You can change the direction of the table traverse, that is one of the beauties of the hydraulic mechanism. You must have cooling to keep the viscosity of the oil the same throughout all the time. Keep it constant. Losses obviously will accrue from slipping. If you get slipping back you get lost efficiency, the oil is not flowing at a constant rate through the pipes. If you could have perfectly tight pistons you would not lose the heat and get nearer to 100 per cent. efficiency.

MR. LEE: For your reversible table why not have air pistons instead of hydraulic pistons?

MR. SCAIFE: Take plunge-cut grinding. You want 40-50 reversed motions per minute, with only perhaps $\frac{3}{16}$-in. movement of the table. There is no other way of doing it, that I know of, as efficient as hydraulic control.

MR. RIPLING: I should like to know whether it is necessary that the shops should be heated to a given temperature, in order to keep correct the viscosity of the oil in hydraulically controlled machines. We start up our works at 8-0 a.m. and whilst we get efficient working

immediately on some makes, on some other machines we get practically nothing until we have been running an hour to warm up. They are very " sluggish " in the mornings.

MR. SCAIFE : Obviously, you are not using the most suitable grade of oil for those sluggish machines. Selection of oil is most necessary. If you are using oil with a pour test at about five degrees below freezing point, immediately below that temperature you will get thickening. With proper oil you do not get that. We have tested two kinds of oil for the job. We have found an " Artic " oil very satisfactory, but unfortunately it is a Russian oil. The oil should be free flowing at freezing point, with a pour test at about 30° F.

MR. ALLEN : I would like to add my appreciation of Mr. Scaife's very interesting paper. I do not propose to be critical in any way but am going to refer to the first part of the paper dealing with cylindrical roller bearings for main spindles. The lecturer mentioned that the rollers had no cages and that they required to be a particularly tight internal fit. The difficulties in getting uniformity of fits in the bearing housings are very great. Very accurate machining is necessary on both bearings and housings to ensure this. I do not think it is a very good plan to use two different types of bearings as shown. The width of one bearing (the self-aligning roller type) is perhaps nearly as great as for the three bearings in the multiple scheme and the rigidity of spindle would be equal. There is no method of adjustment enabling the necessary tightness to be maintained in practice (with the multiple bearing scheme). Why do you favour this type of bearing in preference to that type which is on a well-known make of lathe and is working quite satisfactorily ?

MR. SCAIFE : I remember first putting up that other type of bearing to which you refer to the makers of that lathe and they have used that arrangement since. I am naturally quite in favour of it, but I prefer this type for the reason that I think the other might be inclined to " whip." These are only intended to give the load support. They fit the " housing " like a roller bearing and take out a certain amount of the tendency to " whip." The width of the bearing is nothing like the aggregate dimension of the three bearings in the other case. You will still have " whip " if the shaft is not long enough, otherwise, the main spindle has got to be thicker.

MR. ALLEN : On a well-known make of lathes and milling machines the cylindrical roller bearing scheme is used, but was found unsuitable for high speeds. Taper roller bearings were fitted and the required speed attained. The spherical roller bearing has been used on very many lathes doing very heavy duty.

MR. S. CARLTON SMITH : Surely, it depends on the conditions. Different conditions require other bearings. If you find that you want another bearing at the back you put it in and you get over all

your troubles. Parallel bearings can be made to fine accuracy. The same considerations apply to the design of the bearing itself. Sometimes ball and sometimes roller are more suitable. For some duties the combined journal and thrust bearing is advantageous—sometimes separate bearings to do their respective duties. High speed duties need bearings with cages and do not need to be quite so tightly fitting as for low speed and heavy duty but, on the other hand, the latter bearings do not need cages.

MR. SCAIFE : The roller bearing of the parallel type has to be made to a high degree of accuracy. I say that parallel roller bearings *do the job*, particularly when you get a very high speed coupled with a heavy duty, in which case you have to have the very best bearing possible. We want speeds of 3,000 revolutions per minute. Nothing would answer this requirement except a parallel roller bearing.

MR. LEE : How do you get the air out of the hydraulic system ?

MR. SCAIFE : We get on with the work and the air gets itself out.

MR. LEE : I mean the air itself which does get into the system. It must be got out somehow.

MR. SCAIFE : Design a circuit without a lot of sharp bends, which agitate the oil. We have grown out of that trouble unconsciously and we do not have any difficulties at all now. None of our fitters would be able to answer you because they do not have any trouble. We have never heard of airlock with our machines for some time. Is it not a question of suitable oil ? Are you referring to recent trouble ?

MR. LEE : Yes, and we get over our troubles by fitting a glass capillary tube and the air is found to go up the tube.

MR. WEATHERLEY : With regard to air in the system, if you can keep above atmospheric pressure, air cannot creep in. If you allow any part of the system to fall below atmospheric pressure that is when the air gets in.

MR. G. H. HALES (Member of Council) : I do not agree with all the lecturer says. In the first place, we have heard from our lecturer of the limitation of hydraulic systems. I think it would be rather ridiculous for machine tool designers to get " hydraulic mad." Hydraulic applications to machine tools are in their infancy. Some of the defects mentioned will probably be trimmed down. It depends on the design of the hydraulic system. I should like to hear our lecturer's reasons as to why hydraulic motion is satisfactory. I should like to ask why hydraulic motion is stated by him to be satisfactory for reversing a table of a grinding machine, when the required action of a planing machine table is similar. Why, if faults are apparent in hydraulic control to the table of a planing machine, do these faults not also apply to the action of the grinding machine ? I can see the principle being the same. To my mind, it is purely a question of degree. Referring to broaching machine and jumpiness, the principle is the same. Hydraulics can be applied to machine

tools other than grinding machines—lathes, broaches, milling machines, etc. I agree that we have still a long way to go. There are a number of people working on this problem, some with greater sense than others.—(Laughter). The strides made in recent years have far outshone many other problems. We have to consider the question of cost, whether the hydraulic system will cost more than the mechanical system, also to consider the relative efficiency applied to tooling systems, or whether you are getting better results at a dearer capital outlay which justifies those results.

MR. SCAIFE : You ask why should it be, in my opinion, the greatest advantage to apply hydraulic mechanism to grinding machines. You have in a grinding machine a certain resistance to the movement. Your have a definite resistance to overcome and only a slight additional load due to normal work. Take milling machines on the other hand, perhaps 500 pounds are added on when you come to cutting. This is proportionally a very much greater additional load to your original load. With planing machines the case is the same. The additional load on the operation is so much higher than the normal load due to movement of the table.

MR. WEATHERLEY : Do you know the efficiency of the screw operated broach—in terms of power efficiency—compared to what we term hydraulic efficiency ?

MR. SCAIFE : The actual performance of the hydraulic broach may be more efficient than the screw, but not if you take the efficiency as power consumed from the mains, or source of power supply.

MR. WEATHERLEY : I mean mechanical efficiency.

MR. SCAIFE : Then I say it is not true that the hydraulic system is more efficient than the mechanical screw.

MR. WEATHERLEY : The figures are available to the public which definitely prove it.

MR. BROOMHEAD : Referring to the hydraulic broaching machine, it had a gauge which showed when the broach wanted re-grinding. The addition of a clutch to the screw or rack type of machine achieves the same object. Two machines driven through a Taylor clutch are in operation to-day within 40 miles of us. These machines refuse to pull a broach which requires re-grinding. Mr. Weatherley gave us some wonderful figures as to speed in feet per minute for hydraulic broaching, but these convey nothing unless accompanied by the particulars re materials and other conditions relative to the pieces being broached. Speed is a question of the transmission of power—not a question of the kind of power.

MR. S. CARLTON SMITH : On this question of efficiency we should be very careful what we are talking about, whether it is mechanical or power efficiency, or whether it is efficiency of production. The great point in 1933 is rigidity, and one point not mentioned to-night is the necessity of absence of vibration, particularly to facilitate the

extensive and efficient use of cemented carbide tools. Machine tool manufacturers are making great developments in this direction.

MR. SCAIFE: Absence of vibration coupled with rigidity. Machines with special high speeds are being designed and supplied to meet the requirement of rigidity. I emphasised this point to show the need of this to obtain the results possible with carbide tools and modern methods of tooling. We must realise that we can cut hard materials at normal speeds if we provide these conditions.

MR. R. W. BEDFORD: Mr. Scaife has had a very wide subject to deal with. We have really had two lectures, one on Machine Tool Design and the other on Hydraulic Transmission. He has done justice to both of them. It would have been better, perhaps, if we had dealt with one subject at a time. I have wondered this last hour whether Mr. Scaife was for or against hydraulic transmission. It is an important subject to many of us, who are machine tool users. The time will come when we shall just have pistons, valves and control knobs, and we shall not have anything else. We have got here to-night our record attendance of 110. The discussion has been very keen and most interesting. We have learned a considerable amount about machine tool designs and hydraulic transmission.

A cordial vote of thanks to Mr. Scaife for his paper was adopted.

# MANAGEMENT IN MANUFACTURING.

*Paper presented to the Institution, Manchester Section, by C. T. Skipper, M.I.P.E.*

## Introductory.

MANAGEMENT in manufacturing—the methods used in getting work done—has advanced very rapidly in recent years, resulting in amazing progress in productivity, and, when preparing this paper, I realised that the field I desired to cover is wide, and therefore decided to concern myself chiefly with the fundamentals directly associated with production in general. I do not intend to deal in any way with the financial side of a works organisation, for I think you will agree that each is a complete study in itself, and that both could not be adequately dealt with in the limited time at my disposal.

At the outset let me emphasise that I believe that *systematic control is the foundation upon which most successful business organisations are built.* In this connection it is of paramount importance that the many factors, which make up this system, should be in perfect balance, for however good some parts of a system may be, they cannot work efficiently if some other part of that system is out of balance or ineffective.

If one were to have the opportunity thoroughly to investigate all the different systems which have been developed and put into use from time to time, I venture to suggest that we should find very little new. It is claimed that Nebuchadnezzar, in 600 B.C., had a system for identifying the weekly supplies of yarn which were sent to his mills, by making use of a colour scheme whereby tags were used having different colours for various weekly consignments.

*It is the application of a system to suit existing conditions which is the main point,* and extreme care should be exercised in every case to see that the system put into operation is in its simplest form and without any unnecessary complications.

## Preparation.

We will make a start by considering what is to be manufactured ; a suitable design has first to be prepared, made experimentally, subjected to research, and thoroughly explored before any manufacture can be even considered. This preliminary work is of first importance for *it is just as easy to produce cheaply a badly designed article, as it is a well designed one.*

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*14th November, 1932.*

After the design has been approved, then, all drawings should be handed over for production experts to scrutinise, and make any recommendations which will assist production, without affecting any principle in design. At this point I would strongly emphasise how important it is that there should be a close co-operation between the designer and the production engineer.

When a new design has to be put into production it is often necessary for new equipment to be provided, and this can be reduced to a minimum if some system of standardisation is in being, along with the link between drawing office and works. Splined shafts, broached holes, handles and similar formed bar parts, bolts, studs, nuts, circles of holes, bushes, cover plates, housings, and many other similar components can all be standardised and used wherever possible on new designs, thereby saving considerable expense on new tool equipment. A standard system of limits should also be in use as this will also help to reduce tool and gauge costs to a minimum.

After drawings have been modified to assist production they should be issued finally to the works together with a detailed specification giving particulars of each and every part necessary to complete the unit or machine to be manufactured. This specification is then the basis on which estimates are prepared, materials are ordered, plant requirements are determined, work is planned and progressed through the shops.

A decision has to be made as to the procedure to be used for the machining of materials. The two systems commonly worked, are :—

(*a*) Machining components to maximum and minimum stocks.

(*b*) Machining components to forecasted assembly programmes.

Each of these systems has its own particular advantages and, in deciding which would be the more advantageous, it is necessary to know what practice will be employed for disposing of the finished manufactured article. As a point of discussion the manufacturing of wireless sets selling at £25 will have to be dealt with in a manner different from the manufacturing of a motor vehicle at £750. The whole question is more or less controlled by " supply and demand."

## Materials.

As material management and control are equal in significance to production control, I propose to refer to material control prior to production.

Manufacturing is the transforming of raw materials, or partly manufactured materials, into goods for selling purposes, therefore the controlling of materials becomes a most important part of the manufacturing process.

The actual ordering of materials is naturally governed by the quantities to be manufactured and this fact largely predetermines in what condition the material is ordered, as well as at what price.

Generally speaking, material is the largest proportion of the total cost, and consequently every step should be taken to ensure that it is purchased as economically as possible.

*The highest efficiency in the use of materials is obtained by providing the required quantity, of the required quality, at the required time.*

Although it is sometimes difficult, whenever possible it is an obvious advantage to quicken material turnover, as this considerably reduces the expense of material control.

When placing orders for raw material it is, in many cases, an advantage to arrange for alternative sources of supply ; this safeguards against delays by unforeseen breakdowns on the part of one supplier, and also the business is placed on a competitive basis.

If the raw materials supplied have not been cleaned before delivery, it is essential that arrangements should be made for cleaning by pickling or sandblasting to be carried out immediately after receipt of the rough material. Laboratory analysis tests should also be made as quickly as possible to maintain the standard material specification.

Rough inspection is important as a loss of machine time is often experienced if rough material is allowed to go into production without previously being subject to some degree of inspection. Excessive flashings, distorted castings, and other faults should all be detected before issue and this work can, to a large extent, be minimised by the use of inspection jigs and templates.

## Plant.

Before any actual steps can be taken to prepare for production, a study must be made to determine the actual plant required to deal with the decided output. It is considered necessary that the executives of any organisation, at all times, have before them an accurate survey and record of the capacity of their plant ; so that, when a newly designed unit has to be proceeded with, the new plant requirements can be readily ascertained, after allowances have been made for the new work which can be done on the existing plant which is available. A machine occupation analysis chart is a simple but effective way of dealing with this problem.

Total times per unit can soon be obtained on all the types of machines used, and from this we can get the total hours required on each class of machine for the required number of units per week. Reference is then made to the existing machine occupation charts, to see what time is available on all the existing machines, and finally it is found what new plant will be required. Naturally an allowance has to be made for setting and other contingencies, but averages can be taken over past months which will, to a large extent, cover this point.

Another question now arises as, although machining hours may

be available on existing plant, the quantities of various components under consideration, may justify the installation of single purpose machines. The trend to-day, however, is towards the decline of absolutely single purpose machines, the machine tool designers having co-operated so closely with the users that standard machines have been designed which can readily be adapted to single purpose operations, in many cases 90 per cent. of the machine being standard.

When limited quantities only are available, setting-up time is a factor which, to a large extent, controls the selection of new plant; but, by the use of special tool set-ups kept intact for each job, setting up time can be greatly reduced, thereby, often making it quite a sound proposition to use automatics, multi-cut lathes, and other high production machines, for small quantities regularly required. Drawings of tool set ups are also of great assistance in helping to reduce setting up times, as they provide the operator with all the necessary information as to the tools required and sequence of operations. Generally, the question of the type of machines to be purchased, is one which depends entirely upon a firm's policy and circumstances.

It is, however, one of great importance, and necessitates constant attention, as, *the condition of a firm's plant to a large extent is an indication of the quality of workmanship produced.* Present day competition of necessity demands the most modern of time-saving machinery, and many machines can often be installed, the savings made being such that the cost can be regarded more as a sound investment than a capital expenditure.

The evolution of machine tools during the last decade has been revolutionary, and, if firms do not continually investigate the advantages of new equipment with a view to modernising their shops, then it is more than probable that their machinery will soon be obsolescent and their production costs increasingly prohibitive.

The introduction of new cutting alloys has opened a new field for reducing production costs but even their usefulness is limited if only applied on machines of an old type. Machine tool manufacturers have designed, and put on the market, machines specially built for use with these cutting mediums, so that if maximum efficiency is to be obtained, new plant also must be installed.

I know that there will be a diversity of opinion on these points, but I contend that they are real factors which require the attention of a live management, although at the same time I realise that it may not be possible in many cases to put them into effect.

Sectionalisation of plant has many advantages as it then brings the complete machining of a component, or even the machining and assembling of a unit in its entirety, directly under the control of one person and at the same time should reduce transportation costs to a minimum.

It is appreciated that, in many instances, it is not possible to sectionalise machines, but due care should be taken to eliminate all unnecessary transport of material.

The selection of the plant being made with due regard to the product and quantities to be manufactured, and the design of the parts comprising the product having been reviewed and modified to suit the general factory conditions, the circumstances are now more favourable for economical production assuming that this happy state of affairs is not allowed to deteriorate by injudicious control.

## Planning.

The degree of efficiency attained by a factory is governed in no uncertain manner by " Production Planning " and no phase of the modern factory organisation has received more attention than this. *No matter what methods prevail in any factory they can all be improved upon, and every concern should realise this truism and see that improvements are continually sought after and effected.* The planning department should be regarded as the link between all works departments, and should be given full scope to deal with any manufacturing problems which arise from time to time.

The chief duty of the planning department should be to investigate each part thoroughly and decide what methods of procedure shall be adopted to transform the raw material into a finished part.

The planning staff should have a comprehensive knowledge of the capabilities of the factory equipment and be able to plan broadly and get down to detail. They should give special attention to the quantities to be manufactured, and the layouts they prepare should be complete to the finest point ; it is impossible to give too much information to the works in regard to the methods of procedure.

As the new drawings are received, the planning department must first decide whether it is more economical to machine the part in their own machine shops, or to purchase it from an outside source as a finish machined job. A suitable manufacturing quantity must be decided upon and a complete layout prepared giving the operations necessary to produce the finished article.

Copies of these operation layouts are issued to all the various works departments concerned, and it should be clearly understood that no deviation should be made in the operation route, unless it is absolutely unavoidable, and confirmation from the planning section has been obtained.

In many instances of course it may be necessary to put work into the machine shops before all jigs, tools, and gauges are ready, and this emergency can be met by the issuing of a temporary layout which is worked to, until such times as the final layout, announcing the completion of all equipment comes along.

## Jigs and Tools.

Jigging has been recognised for a great number of years as a necessity in all classes of engineering, the important factor being interchangeability which must be safeguarded this can be satisfactorily done only by the use of jigs, fixtures, and special tools. When quantities are required, then the use of jigs is the means of rapid production as well as interchangeability.

A number of available machining hours will be lost if jigs are not designed with ease of application, and the jig designer has many opportunities of showing his initiative in this direction.

It is advisable that a time study be made of jigs in operation, as the analysis of this will bring to light the success or otherwise of the jig from a handling point of view. You will probably all have had experience of jigs which behave like money boxes, once a part is placed in the jig and machined, it is practically impossible to get it out without using considerable force.

I do not intend to discuss the fundamental principles of jig design as, to a practical engineer, these are obvious. I would, however, stress the importance of actual shop experience being necessary to a jig designer, for as well as having a psychological effect, it gives him a knowledge of troubles an operator is likely to come up against.

Briefly, jigs should be designed so that the job is easily loaded, elaborate setting devices should be avoided, clamps should be accessible and operated with quick motions ; in fact loading time should be reduced to a minimum. In many cases, milling for instance, it is possible to eliminate loading time altogether by the use of a swing table made to accommodate one jig on each end ; the operator can then load one jig while the other is in operation, also when it is possible to cut on dead centre it can be arranged for two jigs to be used with the cutter between them and feeding in either direction.

The making of jigs and tools is worthy of a few moments consideration as they are invariably required immediately ; I consider therefore that a progressive system is necessary to look after jigs in course of manufacture. This system should take care of the jig from the time of its inception in the jig office, until it has been made, tested, and delivered to the stores for shop use. There are several methods of doing this but, providing such a system is able to show exactly the position of a jig in progress, there is no further need to stress this point.

When testing a jig to prove its accuracy, the conditions are often somewhat different from those to which it will be subjected when in production, but during the test, useful information can be obtained. It is advisable that this should be recorded on a jig test card which can then be forwarded to the rate fixing department for scrutiny.

The actual manufacture of jigs and tools is dependent upon the

efficiency of the tool room, and facilities should be provided whereby this department can function on lines as advanced as those which appertain throughout the works.

## Progressing.

To carry on the work of the planning department with any degree of success, it is necessary to establish a department which is entirely concerned with works routine. I refer to the progress department, and no matter how small or how large a factory may be it is certain, that without such a department, the results of even the most careful planning will be disappointing. Planning is something possible, but something uncertain, and it is the duty of the progress department to make it a reality. In other words the planning result is directed into proper channels, and is given the opportunity to demonstrate in practice the soundness of the theory. The planning staff who decide on the operation layout know that work *can* be handled on a certain machine, and that it *can* be completed in a given time, but it is for the progress staff to see that this *will* be done. *Left to itself "planning" makes but little headway, but worked in conjunction with "progressing" it becomes a scientific force which is the basis of modern manufacture.*

The functioning of the progress department begins when it is necessary to put work into the shops, and when a factory is engaged on repetition or even semi-standard work, and a specified output is to be obtained, it is the duty of the progress department to see, that if an output of 100 units per week is required, then 100 sets of castings, forgings or other raw materials are available, and 100 sets of parts are delivered to the finish stores each week. Daily records should be prepared of orders overdue, orders awaiting receipt of rough material, machinery standing idle with reasons, etc.; these should be submitted to the works manager's department for perusal and attention.

It is also essential that the progress department should keep closely in touch with the designs office so that when alterations in design are likely to be introduced, first hand knowledge can be obtained and stocks arranged accordingly.

## Ratefixing.

Ratefixing is rather a delicate subject, and I know that I shall have to approach it very carefully, for we have so many experts on "payment by results."

The payment for production work on a flat hourly rate is nowadays being discontinued, even in the smallest factory ; this is being superseded by a method of payment which provides an incentive to the operator. Except under exceptional circumstances, there is no denying the fact that a bonus system of payment is necessary to obtain economical production, as with it, output is increased, manu-

facturing costs are reduced, and generally speaking a better feeling exists throughout the factory.

There are several well-known systems working more or less satisfactorily, but the one I favour is the straight bonus on time system void of all frills and complications.

My experience has been that piece work is approved by the men in the shop, but successfully to put this system into operation, *it is a vital necessity to have ratefixers who are thoroughly practical men of integrity.* However carefully rates are fixed there will always be disputes, but naturally the fewer disputes the better, which makes it necessary for ratefixers to endeavour to obtain the confidence and goodwill of the men. It is not enough for the ratefixer to know all about the theoretical capacity of the machine by means of feed and speed calculations, but *he must know the capabilities of the machine in relation to the specific job, the special facilities provided for that job, and the capabilities of the operator.* This latter point is most important for in many cases it is an unknown quantity ; and in this connection it is often advisable to lay stress upon the necessity of getting the right man for the job, or conversely giving the job to the right man.

Rate setting that yields abnormally high results by way of bonus, is obviously uneconomical, and it is evident at once that the ratefixer responsible for setting the time, knew little of the operation, or the various points relative to it. Attempts at rate cutting are disastrous, for they break down the confidence of the men and are fiercely combated by operators, who then adopt a policy of " easing up," in order to keep the bonus earned within reasonable limits. It is understood that the methods adopted for actually fixing the rates must vary according to the class of work which is being done, but whenever possible rates should be fixed before the work is issued to the machines.

The practice, however, of fixing rates while the work is in progress, is one which is used considerably and found to be favoured by certain operators ; it gives them an opportunity to see what bonus they can make under actual conditions before the rate is definitely fixed. When this method is adopted I strongly recommend that the ratefixer should assume a very open attitude, and inform the operator of his intentions ; the more or less underhand method of having a stop watch concealed without the operator's knowledge is to be condemned ; rather, the ratefixer should give the operator the benefit of his experience, so that a good rate can be fixed, one which is fair to the employee and also to the employer. In fact in many cases a ratefixer should be a good salesman, so that he can leave the operator under the impression that he has got the best of the bargain, whereas a fair time has actually been given.

The fixing of a time or rate after the job has been completed

should be avoided whenever possible, as the principle of incentive is thus defeated.

In the case of sectionalised machines, sub-assemblies, etc., it is often possible to arrange for all men to work on a collective, instead of individual basis, whereby the men's bonus is based on the total weekly output obtained from the section. This practice is often advantageous, especially where it is not possible to arrange all operations of the same duration. Where each man is dependent upon all other men in the section, you will often find a spirit of co-operation working throughout that section for, by helping his neighbour, a man is automatically helping himself.

## Inspection.

It is a fact that quality of necessity costs more to produce than quantity, and a manufacturer may, and often does, conclude that quantity rather than quality of output must be his first aim as a producer. As a matter of fact the reverse is true, as "*when quality is controlled, quantity takes care of itself*."

Inspection is a most important part of a works organisation, for I think I can safely say that *the quality of a product often establishes a market for itself*, and this being so, it has to be carefully maintained. Inspection staffs are often looked upon as a necessary evil, but as they control the standard of workmanship, one cannot emphasise too strongly their responsibility.

Opinions differ as to whom the inspection department should be responsible ; I am of the opinion that they should be absolutely free from the control of production engineers who are directly connected with production, otherwise it is more or less a case of people inspecting their own work.

The general efficiency of inspection methods has advanced rapidly in recent years, due to the very accurate instruments which are now available, and parts can be inspected purely as a mechanical operation, without requiring any skill from the operator.

For the internal inspection of castings, previous to machining, the X-ray process is now being used commercially with satisfactory results, and it may also be of interest to refer to a device which is used extensively for detecting defective material externally, which previously could only be inspected by the eye ; this being the magnetic crack detector. The basic principle of this instrument is the well known fact that magnetic lines of force will always tend to straighten themselves, if the deviating path is filled with magnetic, instead of non-magnetic material. To illustrate this to the mind's eye, the cracks can be likened to a deep vee cut into a steel shaft, which is magnetised at right angles to the vee, the magnetic lines will not of course travel through or across the vee until the vee is filled with magnetic material. When this is applied, the crack is definitely

shown and the material is retained by the magnetism until the inspection is completed; then, the component under test is demagnetised.

Briefly, some outstanding points relative to inspection are:

(1) Accuracy of gauges and inspection fixtures must be carefully controlled.

(2) A suitable system should be enforced enabling a part once passed, to be easily traced back to the inspector responsible.

(3) Careful records should be made of all scrap work, together with an investigation being made as to the cause, so as to prevent recurrence.

The flexibility of limits is greatly influenced by the type of work being machined.

Greater tolerances are permissible when selective assembly methods are employed, this also reduces material scrap, which is so very necessary in the case of a comparatively cheap commodity, which is made in large quantities. This practice cannot always be made use of, for, with its adoption, the safeguard of interchangeability is greatly reduced; consequently closer tolerances have to be worked to.

## Drawings.

The accuracy of the prints or drawings, which are issued to the works, is another point worthy of consideration. As a rule, modifications are often made to drawings, and a system is necessary to make sure that only correct drawings are in existence; *in a well organised factory it should not be possible to find an incorrect drawing in the shops.* Where such a state of affairs exists, there need be no hesitation about giving the instruction "work to drawing," and there will be no need for individual conceptions on various points; a standard will be set up, but this being so, it should be carefully controlled.

I know of instances where it is customary for the shop foreman to make machining alterations to parts, where he finds it necessary, the drawings of the parts are not brought in line, and his memory is trusted for the future. This procedure is one which should be strictly avoided.

In almost every works, alterations to detail are constantly being made, emanating from various sources, such as, limits requiring adjusting, the suggestion of a change in material, operations being unnecessary, etc., etc. As these are made, they should be sent to a central clearing station, or a department appointed, whose duty it is to record the suggestions and then forward them to the designs office for consideration; attached to the suggestion should be an answer slip, for the designs office to return giving their decision, whether the suggestion is approved or otherwise. A review of the

outstanding suggestions should be made periodically, to see whether prompt attention is being given to them, and a report submitted when further action is necessary.

**Stores.**

I shall only refer briefly to the storage of materials, although this problem has a prominent place in modern shop organisation. Stocks, both rough and finished, represent a considerable portion of the capitalised value of a business, and consequently *materials should be accounted for as carefully and scrupulously as actual cash.*

Where it is not possible to operate the system on continuous or flow production lines, the rise and fall of stocks require very careful control.

All stores should be regarded as private, and a careful check of all parts booked " in " or " out " as the case may be. There are several excellent systems for the actual recording of parts contained in a stores, and if one of these is worked in conjunction with a plan showing the allocation of all bins, etc., little difficulty should be experienced in rapidly executing material requisitions.

**Factory Services.**

Factory services comprise the following :

(1) Motive power for driving the machinery to give production.
(2) Steam, water, gas, and compressed air supplies as aids to production.
(3) Heating, lighting, and ventilation to help to maintain quality of production.
(4) Maintenance of buildings, production, and service plants, to ensure continuous production.

In all cases it is essential that the factory services should be efficient, reliable, and above all continuous. " *Continuity of supply* " *is a familiar phrase these days but the maintenance of this is not so well known.*

The trend of modern motive power practice is towards the use of electricity for as many purposes as possible. Electricity is, in these times, a relatively cheap form of power service, and, due to the inauguration by the Electricity Commissioners of what is popularly referred to as "The Grid System," it provides a reliable and continuous power supply.

Steam, however, still has many places of application for factory driving, especially where there is an abundant supply of good boiler feed water, and fuel at cheap rates.

**Heating, Lighting, and Ventilation.**

The above three factory services have been classed as aids to quality of production, but they play a great part also in helping continuous and economic working. Factories are operated at their

best, under conditions of correct temperature, light intensity, and air circulation, these remarks apply equally well to the persons who operate the machines.

As much daylight as possible should be arranged in all factories by means of window spaces, and in regard to artificial lighting, a steady light of the proper intensity should be provided at the points where the work is done. Diffusion should be uniform, for bright and dark patches are conducive to the occurrence of accidents, and the lighting units themselves should be arranged so that the actual source of light never comes within a direct line of vision to the operative's eye.

It follows that just as good light is a necessity of production, so is an adequate ventilation system. The air conditions of a factory have a considerable economic effect; poor air conditions mean improper temperatures and humidity, which naturally have an adverse effect on the vitality of the workpeople, resulting in lowered production. Proper ventilation also is decidedly useful for the natural cooling of buildings, machinery, and materials.

## Maintenance.

This has been described as the routine which maintains efficiency, and taken in the long run, this section more than pays for itself. A good criterion of the efficiency of the works maintenance department is its behaviour in an emergency. Short of unforeseen causes, stoppages should be prevented, not remedied, if continuous and reliable running is to be the rule; but when the unexpected happens. *the value of a well organised maintenance staff will be shown by the expediency with which operations are restarted after a sudden and unexpected breakdown.*

## Labour.

The control of the personnel of any factory should be given very careful attention, and I believe that this can best be done by creating organised channels through which all direct labour troubles can be taken for settlement.

The change in the attitude of management towards the worker from ancient times, or even from the Victorian age, to the present day, well illustrates how the fundamentals of modern management have brought a large degree of economic freedom. From the days of serfdom, when the spirit of the master to his servants was an attitude of " make the wretches work," we have found the outlook gradually broadening until the practice nowadays, is to " teach and lead the workers and so develop active co-operation between them and their employer."

Labour administration is difficult at all times, and in order to completely deal with it, any works of a reasonable size should have its own personnel or labour department, under the control of an *employment manager, who must be a man of wide experience, coupled*

*with a personality which will encourage the men openly to discuss with him any troubles real or imaginary*; he should be looked upon as the bridge between employer and employee.

His department should keep careful records of relevant particulars of all employees, appertaining to their experience, general ability, character, etc., and be in a position to co-operate with the works manager when promotions are under consideration. Higher personal efficiency is established throughout a works where it is known that outstanding ability will be recognised, for thereby an incentive is created.

This section should also be concerned and the fitness, safety, and welfare of the workpeople for, by helping to secure recognition of ability, as well as generally looking after the men's welfare, *the labour department tends to break down antagonism and render the work of production easier.*

The establishing of a department of this nature, also enables workers to be dealt with as individuals, and to be shown that loyalty to the firm is not inconsistent with loyalty to themselves or their union. I am convinced that if a spirit of fairness, together with firmness, were more often exercised, the result would be that some of the present industrial differences would become more negotiable.

A system which I have found to have many advantages is one where the men in each section of a works elect their own representative, to look after the interests of the whole of that section, he being authorised to deal direct with the labour department. By meeting these men, who form a works committee, once each week along with the employment manager, the works manager has the opportunity of obtaining first hand knowledge of any points which are likely to develop and cause trouble. He can then deal with these promptly and thereby often " nip in the bud " something which might otherwise have spread, with serious consequences.

## Suggestions.

The value of what is commonly known as the " suggestion box " is often debated, as to whether or not this is worth while. Its main aim is to encourage the workers to take a greater interest in their work, and at the same time, perhaps secure some reward for a suggestion which is accepted as useful ; incidentally, the firm is sometimes able thus to get hold of a really sound idea.

It must be readily agreed that, among the thousands of employees in a large concern, there must be a few at any rate who have brains above the average, but whose daily task precludes them from putting their brains to the fullest possible use. The suggestion box is an outlet whereby these men are given the opportunity of showing any outstanding ability, often to the mutual advantage of themselves and the firm.

## Safety First.

The elimination of the hazards in modern manufacturing conditions is worthy of the closest study. Safety is far better than compensation and, although it is realised that the majority of accidents are due to the failure of the human element, yet steps should be taken to supply machine guards and similar safety devices wherever possible.

*Organised safety work is best carried out by co-operation, rather than authoritive enforcement*, and employees should be more or less educated into the observance of safety first methods.

Suitable posters should be displayed about the works and it has been found advantageous to publicly record the nature of all accidents occurring in the works with the view of impressing upon all operatives the necessity of taking every care to avoid a repetition.

It should be definitely laid down that all accidents, even the minor cases, should be recorded and analysed, and every shop should have its first aid or ambulance room set apart to deal with any accidents which might occur.

## Social.

Before leaving the question of welfare and its relation to successful management, I would refer to the social element which tends to co-ordinate a team spirit of equality and goodwill. This should be fostered whenever possible, and an active interest taken by senior members of a works organisation. It can be achieved by the firm having its own sports and social club, but where this is not possible, works' trips, lectures, etc., can be arranged which are of mutual interest and pleasure. In this latter connection I have been one of a party of 2,000 who have visited Ostend, Paris, and Dublin, without a hitch of any description.

## Conclusion.

As the various factors making up a business are considered, one cannot reflect on the subject of human engineering, without realising the tremendous responsibility that rests upon management in its relation to mankind in general. True management, from my own point of view, reaches out beyond the developing and operating of plants, beyond the problems of production, into those of administrative and executive functions, bringing us face to face with the greater problems of human relations in industry.

*It cannot be over-emphasised that wise leadership is more essential to the success of any enterprise than an extensive organisation or the most modern equipment.*

As referred to previously, management must be ever open to new thoughts and methods, as well as being receptive to the proposals of subordinates, who should receive due encouragement.

The managing executive must have a clear vision of the aims of an undertaking and exercise judicious thought in fixing responsibilities; the personal touch helps a great deal to the successful managing of any concern.

*In conclusion, I would say that the essence of modern management is the application of scientific methods, well thought out and developed to replace the old order of uncertainty, chance, and fortuitous results.*

# ANNUAL REPORT

and

# ACCOUNTS

## For the Year ended 30th June, 1933

To be presented at the

## ANNUAL GENERAL MEETING,

20th October, 1933,

Holborn Restaurant, London,

at 6 p.m.

# THE INSTITUTION OF PRODUCTION ENGINEERS.

## Balance Sheet as at 30 June, 1933.

| Liabilities. | | | | £ | s. | d. |
|---|---|---|---|---|---|---|
| Sundry Creditors ... ... ... ... ... | | | | 113 | 0 | 11 |
| Subscriptions received in advance ... | | | | 20 | 6 | 0 |
| Sir Herbert Austin Prize Fund ... ... | | | | 52 | 10 | 0 |
| Income and Expenditure Account: | | | | | | |
| Balance at 1 July, 1932 ... | £871 | 6 | 11 | | | |
| *Add* Excess of Income over Expenditure for the year | 161 | 11 | 9 | | | |
| | | | | 1032 | 18 | 8 |

| Assets. | | | | £ | s. | d. |
|---|---|---|---|---|---|---|
| Furniture, Fittings, and Plant: | | | | | | |
| At cost, less amount written off | | | | | | |
| Balance at 1 July, 1932 ... | £96 | 11 | 10 | | | |
| Additions during the year . | 35 | 3 | 8 | | | |
| | 131 | 15 | 6 | | | |
| *Less* amount written off ... | 30 | 18 | 5 | | | |
| | | | | 100 | 17 | 1 |
| Investments: | | | | | | |
| £936 5s. 0d. 2½ per cent. Consolidated Stock at cost | 716 | 5 | 7 | | | |
| *Less* net profit on re-investment ... ... ... | 58 | 8 | 8 | | | |
| (market value £680 19s. 2d.) | | | | 657 | 16 | 11 |
| Sundry Debtors: | | | | | | |
| General... ... ... ... ... | 224 | 19 | 2 | | | |
| Subscription arrears ... ... | 101 | 0 | 0 | | | |
| | | | | 325 | 19 | 2 |

| | £ | s. | d. | | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | PRELIMINARY EXPENSES: | | | | | | |
| | | | | Balance at 1 July, 1932 ... | 55 | 16 | 0 | | | |
| | | | | *Less* amount written off ... | 55 | 16 | 0 | | | |
| | | | | CASH: | | | | | | |
| | | | | At Bank ... ... ... ... | 121 | 4 | 0 | | | |
| | | | | In hand ... ... ... ... | 12 | 18 | 5 | | | |
| | | | | | | | | 134 | 2 | 5 |
| | £1,218 | 15 | 7 | | | | | £1,218 | 15 | 7 |

AUDITORS' REPORT.—We have audited the above Balance Sheet dated the 30th June, 1933, and we have obtained all the information and explanations we have required. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Institution's affairs according to the best of our information and the explanations given us and as shown by the books of the Institution.

34-36, Oxford Street, London, W.1.
12th September, 1933.

(*Signed*) C. H. APPLEBY AND COMPANY, Auditors.
*Chartered Accountants.*

(*Signed*) S. CARLTON SMITH, *Chairman of Council.*
(*Signed*) ROBT. HUTCHINSON, *Chairman, Finance Committee.*
(*Signed*) R. HAZLETON, *General Secretary and Treasurer.*

# THE INSTITUTION OF PRODUCTION ENGINEERS.

## INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30 JUNE, 1933.

| Dr. | £ | s. | d. | Cr. | | | | £ | s. | d. |
|---|---|---|---|---|---|---|---|---|---|---|
| To Salaries ... ... ... ... ... ... ... | 751 | 15 | 9 | By Subscriptions for 1932-33 : | | | | | | |
| ,, Rent, Lighting, Heating, and Cleaning ... ... ... ... ... ... ... | 140 | 11 | 8 | Received ... ... ... | £1502 | 3 | 0 | | | |
| | | | | Outstanding ... ... | 101 | 0 | 0 | 1603 | 3 | 0 |
| ,, Local Section Expenses ... ... ... | 255 | 10 | 8 | ,, Interest on Investments ... | | | | 16 | 10 | 4 |
| ,, Printing, Postages, Stationery, Telephone, and Certificates ... ... ... | 164 | 15 | 1 | ,, Receipts from Sales and Advertisements of Journal | | | | 622 | 3 | 8 |
| ,, Printing, Postage, and Stationery—Journal and Bulletin ... ... ... | 436 | 10 | 5 | | | | | | | |
| ,, Staff Travelling and Expenses of General Meetings ... ... ... ... | 83 | 19 | 7 | | | | | | | |

| | £ | s. | d. | | £ | s. | d. |
|---|---|---|---|---|---|---|---|
| ,, Legal Charges, Audit Fee, Valuation, and Insurances ... ... ... ... | 58 | 17 | 8 | | | | |
| ,, Library ... ... ... ... ... ... ... | 20 | 14 | 8 | | | | |
| ,, Examinations ... ... ... ... ... | 3 | 11 | 3 | | | | |
| ,, Annual Dinner ... ... ... ... ... | 16 | 13 | 11 | | | | |
| ,, Subscriptions written off ... ... ... | 49 | 18 | 0 | | | | |
| ,, Amount written off Furniture, Plant, and Preliminary expenses ... ... | 86 | 14 | 5 | | | | |
| ,, Sundry Office Expenses ... ... ... | 10 | 12 | 2 | | | | |
| ,, Balance, being excess of Income over Expenditure ... ... ... ... ... | 161 | 11 | 9 | | | | |
| | £2,241 | 17 | 0 | | £2,241 | 17 | 0 |

# ANNUAL REPORT FOR 1932-33.

## *To be presented by the Council to the Annual General Meeting, London, 20th October,* 1933.

### Membership.

The membership at the end of June, 1933, was made up as follows :

| | |
|---|---|
| Ordinary Members ... ... ... | 414 |
| Associate Members ... ... ... | 346 |
| Graduates ... ... ... ... | 58 |
| Associates ... ... ... ... | 32 |
| Affiliates ... ... ... ... | 13 |
| (Twelve affiliated firms). | |
| Hon. Members ... ... ... | 3 |
| | 866 |

One hundred and forty-two new members completed election during the year, thirty-four members resigned or lapsed, and there were four deaths, including the death of Mr. Henry Mantell, Member of Council, whose decease was a heavy loss to the Institution. At June 30th, 1933, the membership was distributed among the various sections as follows :

| | |
|---|---|
| Birmingham Section ... ... | 207 |
| Coventry Section ... ... ... | 100 |
| Eastern Counties Section ... ... | 14 |
| Glasgow Section ... ... ... | 76 |
| London (London area) Section ... | 216 |
| ,, (Country area) Section ... | 23 |
| ,, (Overseas area) Section ... | 22 |
| Luton, Bedford, and District Section ... ... ... ... | 64 |
| Manchester Section... ... ... | 87 |
| Sheffield Section ... ... ... | 18 |
| Yorkshire Section ... ... ... | 39 |
| | 866 |

### Finance.

The audited Annual Accounts for 1932-33, presented with this Report, show that the Institution continues to maintain a satisfactory financial position.

## Examination Scheme.

There was a slight increase in the number of entries for the 1933 Graduate Examination, as compared with previous examinations, but the greater interest now being shown in the scheme by technical colleges in various parts of the country should lead in the near future to considerably increased entries. The scope of the examination is being widened and after 1934 it will extend over two days instead of one.

## Sir Herbert Austin Prize.

The winner of this prize at the 1933 examination was Mr. Percival C. Redwood, Birmingham, who has since been elected a Graduate of the Institution.

## New Local Sections.

During the year two new local sections were opened in Yorkshire, one with headquarters at Leeds, entitled the Yorkshire Section, and the other at Sheffield. Both promise to have a successful future. In addition, the first Graduate Section of the Institution was opened at Birmingham under very favourable auspices. A further local section, to be known as the Western Section, with headquarters at Bristol, is being opened in November, 1933. It has been decided to postpone the opening of a South African Section for the present. Two sections, London and Birmingham, having reached a membership of 200, became entitled during the year to one additional member of Council each.

## Advisory Committee to City and Guilds Institute.

As a result of the urgent representations of the Institution, the Board of Education has now given permission to the City and Guilds of London Institute to hold the intermediate examination in machinists', turners' and fitters' work. It is worthy of note that the final negotiations with the Board of Education were left to the Institution's representatives on the Advisory Committee, and that the settlement arrived at has been made applicable to the examinations of several trades in addition to machinists', turners' and fitters' work.

## Proposed Alteration in Memorandum and Articles of Association.

An extraordinary general meeting of members is being called for on October 20th, 1933, to be held immediately following the annual general meeting, when the Council propose to put forward certain alterations which they recommend should be made in the Memorandum and Articles of Association. The alterations recommended in the Memorandum are designed to safeguard and clarify the posi-

tion of the Institution as a scientific body, and have been drawn up by eminent counsel with this end in view.

The proposed alterations in the Articles of Association cover mainly the age limits of certain membership grades. It is recommended that in future the minimum age for Ordinary Membership be 33 instead of 30, for Associate Membership 28 instead of 25, and that Graduates be admitted up to the age of 29 instead of 25. It is believed that these alterations will bring the membership grades concerned more into conformity with the needs of the position and strengthen the Institution. It is also recommended that the following new clause be added to the Articles : " No member shall abuse his connection with the Institution to further his business interests. Any member adjudged by the Council to have contravened this article is liable to be removed from the Register of Members."

**Syllabus for Associate Membership Examination.**

At the request of the Council, the Examinations and Research Committee has drawn up a syllabus for an Associate Membership examination, but no steps to put this into operation are at present contemplated.

**Papers and Meetings.**

The formation of new local sections has caused a steady growth in the number of lectures, and attendance at these has been well maintained throughout the country. The policy of consulting members as to the subjects to be dealt with has proved very helpful. The subject selected by ballot this year, and approved by the Council for discussion at all local sections during the 1933-34 session, is " Estimating Methods." Last session's selected subject " Standardisation " will be fully dealt with in the December issue of the Journal.

**The Journal.**

The price of the JOURNAL has been raised from 1s. 0d. to 5s. 0d. per copy. Though the revenue from advertisements continues to grow, the cost of publication, as the JOURNAL is enlarged, necessarily increases as well. While it is not the policy of the Council to make a profit from its publication, it is satisfactory that the JOURNAL can be issued without entailing any considerable charge on the resources of the Institution.

**The Library.**

The first edition of a library catalogue was published during the year, and while the building up of a useful collection of books must be a very gradual process, numerous additions have been made, by way of presentation and purchase, in recent months. Two new bookcases have been acquired. An increasing use is being made, by members and others, of the facilities afforded by the Library.

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